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REVIEW ARTICLE

"Haripriya" God's Favorite: *Anthocephalus cadamba* (Roxb.) Miq. - At a Glance

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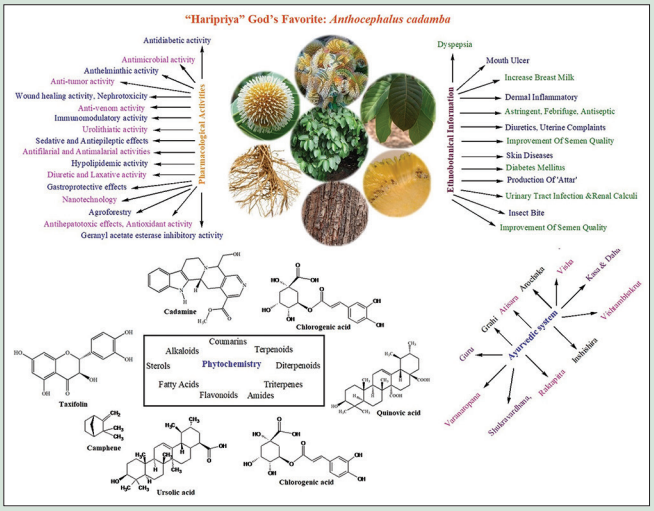
ABSTRACT

The Kadam tree is highly regarded as religiously and culturally in India being sacred to Lord Krishna, and hence, the tree is also known as Haripriya, God's favorite. This article provides a detailed review of *Anthocephalus cadamba* (Roxb) Miq. (family – *Rubiaceae*) that covers taxonomical classification, vernacular names, geographical distribution, botanical description, ethnobotanical information, pharmacological studies, and phytochemistry. Several parts of this plant have a number of traditional applications for treating humanity, which includes mouth ulcer, subdermal inflammatory deposits, stomatitis, fever, gastric disturbance, astringent, febrifuge, antiseptic, diuretics, anemia, uterine complaints, increase breast milk in lactating women, improvement of semen quality in men, nanotechnology, and agroforestry. The plant parts produce various pharmacological activities such as antidiabetic, antioxidant, antitumor, nephrotoxicity, diuretic and laxative, antihepatotoxic, hypolipidemic, analgesic, antipyretic, anti-inflammatory, antifilarial antimalarial, sedative, antiepileptic, urolithiatic, immunomodulatory, antivenom, gastroprotective, anthelminthic, wound healing, antimicrobial, geranyl acetate esterase inhibition along with toxicological studies, nanotechnology, and agroforestry, which are newly added applications. Many phytoconstituents were isolated using various solvents and obtained compounds, such as cadambine, 3α-dihydrocadambine, isodihydrocadambine, β-sitosterol, amygdalin, phelasin, ursolic acid, linalool, and geraniol that belong to alkaloids, coumarins, terpenoids, diterpenoids, triterpenes glycosides, sterols, flavonoids, amides, and fatty acids. Various solvent extracts and their gas chromatography–mass spectrometry studies have confirmed structures of some important phytoconstituents. Hence, this review can be a good reference for researchers who are willing to continue further research about *A. cadamba*.

Key words: *Anthocephalus cadamba,* ethnobotanical information, Haripriya, pharmacological activities, phytoconstituents

SUMMARY

- *Anthocephalus cadamba* (Roxb) Miq. (Family — *Rubiaceae*) is commonly known as Haripriya or God's favorite due to love flute of Lord Krishna and Radha under this tree shades. This article contains detailed information about taxonomical classification, vernacular names, geographical distribution, botanical description, ethnobotanical information, pharmacological studies, and phytochemistry. It posses several pharmacological activities that includes antidiabetic, antioxidant, antitumor, nephrotoxicity, diuretic and laxative, antihepatotoxic, hypolipidemic, analgesic, antipyretic, anti-inflammatory, antifilarial antimalarial, sedative, antiepileptic, urolithiatic, immunomodulatory, antivenom, gastroprotective, anthelminthic, wound healing, antimicrobial, geranyl acetate esterase inhibition along with toxicological studies, nanotechnology, and agroforestry and many phytoconstituents were isolated from this plant that belongs to alkaloids, coumarins, terpenoids, diterpenoids, triterpenes glycosides, sterols, flavonoids, amides, and fatty acids. Gas Chromatography-Mass Spectrometry analysis confirmed structures of a number of phytoconstituents.



Abbreviations Used: *A. cadamba*: *Anthocephalus cadamba*, *A. niger*: *Aspergillus niger*, ABTS: 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid), ACALK: Alkaloid-rich fraction, *B. subtilis*: *Bacillus subtilis*, *C. albicans*: *Candida albicans*, CCl_4: Carbon tetrachloride, CGA: Chlorogenic acid, cm: Centimeter, COX-2: Cyclooxygenase-2, DNA: Deoxyribonucleic acid, DPPH: 1,1-diphenyl-2-picrylhydrazyl, *E. coli*: *Escherichia coli*, EAC: Ehrlich ascites carcinoma, g/ml: Gram/milliliter, GAE: Geranyl acetate esterase, GI_{50}: Growth inhibition 50%, IASM: Indian Ayurvedic System of Medicine, IC_{50}: Half maximal inhibitory concentration, IL-2: Interleukin-2, INH: Isoniazid-induced seizures, LC_{50}: Lethal concentration 50, m: Meter, MBC: Minimum bactericidal concentration, MES: Maximal electroshock-induced seizures, mg/kg: Milligram/kilogram, MIC: Minimum inhibitory concentration, ml: Milliliter, *P. aeruginosa*: *Pseudomonas aeruginosa*, PTZ: Pentylenetetrazole-induced seizures, RBC: Red Blood Corpuscle, *S. aureus*: *Staphylococcus aureus*, *S. typhi*: *Salmonella typhi*, SOD: Superoxide dismutase, μg/ml: Microgram/milliliter, μm: Micrometer.

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INTRODUCTION

Since the beginning of human civilization, medicinal plants have been used by humanity for its therapeutic value. The connection between human and his/her search for drugs in nature dates from the far past, of which there is ample evidence from various sources: written documents, preserved monuments, and even original plant medicines. The knowledge of the development of ideas related to the usage of medicinal plants as well as the evolution of awareness has increased the ability of pharmacists and physicians to respond to the challenges that have emerged with the spreading of professional services in the facilitation of human's life.

The Kadam tree is highly regarded as religiously and culturally in India being sacred to Lord Krishna. Radha and Krishna conducted their love-play in the hospitable and sweet-scented shade of the Kadamba tree. In Hindu mythology, the Kadam tree is the favorite tree of Lord Krishna, who is usually depicted playing his flute under it. He also used to play with his friends under the Kadam tree in Vrindavan using the unique globular flower of the tree. Hence, the tree is also known as Haripriya, God's favorite. The word Kadamba lends its name to the Kadamba Dynasty which ruled from Banavasi in what is now the state of Karnataka from 345 AD to 525 AD. The Kadamba tree was considered a holy tree by the Kadamba dynasty. Kadambotsava ("The festival of Kadamba") is also the festival that is celebrated every year by the Government of Karnataka in honor of the Kadamba kingdom.[1]

India has a wide variety of medicinal plants popularly known as the Indian Ayurvedic System of Medicine. *Anthocephalus cadamba* (Roxb) Miq. (Family *Rubiaceae*) is commonly known as "Kadamba" in Ayurveda.[2] It is said to be one of the most valuable medicinal evergreen tropical trees because of its greatest medicinal value in Ayurveda – an Indian native system of medicine. Kadamba is a plant drug that is widely used in many instances in the classical Ayurvedic texts for various ailments.[3-5]

Charaka mentioned Kadamba to be used as vegetable and fruit.[6] Sushruta has described it in the first group of sour fruits.[7] Sushruta has mentioned Kadamba and Nipa as two different plants. However, in most instances, Kadamba and Nipa are used as synonyms.[7] It is widely distributed in India, Bangladesh, Nepal, Sri Lanka, Myanmar, Philippines, Indonesia, and Papua New Guinea. The trees found in the greater part of India in moist locations in West Bengal, Bihar, Odisha, Andhra Pradesh, Karnataka, Kerala, and peninsular India.[8] It is also found in the sub-Himalayan tract from Nepal eastward on the lower hills of Darjeeling terai in West Bengal; it is very common tree found in damp places along with large streams in Chota Nagpur (Bihar), Odisha and Andhra Pradesh, in the Andaman, on the west coast of Karnataka and Kerala also found at low-level wet places of Western Ghats. It is also distributed in Thailand and Indo-China and eastward in Malaysian archipelago to Papua New Guinea.[9,10] The tree is said to have a medium-to-large-sized deciduous tree attaining a height of 20–40 m and a girth of about 2–2.5 m along with clean cylindrical branches and rounded crown. It is habitually found on the slopes of evergreen forests which are spread all over India which are up to 500 m. The stem of younger trees appears grayish-green with smooth bark. As it gets older, the bark gets rough and gray with longitudinally fissured.[11] Leaves are glossy, dark green, opposite, simple pulvinus base subsessile to petiolate, broadly ovate to elliptic-oblong, entire apex mucronate, and venation pinnate. The flowers that appear from August to October are orange to yellow. Inflorescences are clusters with terminal globose heads, subsessile and fragrant. Fruitlets are numerous with upper parts containing solid structures along with tiny seeds which are trigonal or irregular in shape.[8] The species occurs in wooded grasslands, deciduous woodland and bushland, and riverine and groundwater forests in altitudes between sea level and 1500 m.[12]

A. cadamba has been known for curing a number of diseases; particularly, the extract prepared from the bark and leaves is crucial.[13] The barks and leaves of the plant are reported to have various medicinal uses such as astringent, antihepatotoxic,[14] antidiuretic, wound healing, antiseptic,[15] and anthelmintic.[16] The pharmacognostical study of leaves, roots, and stem bark of the plant is also reported.[17] Various researches across the world have focused their studies on discovering a number of phytochemicals as well as secondary metabolites (saponins, triterpenes, indole, and quinoline alkaloids) with pharmacological significance from the *Cadamba*.[18-20]

In India, *A. cadamba* is a well-known plant for its rapid growing in several climatic conditions. Due to its rapid-growing nature, it is highly popular tree as supply of wood in various farmlands and in agro factory. *A. cadamba* woods are creamy-white and straight grain having medium texture wood that is commonly used in multipurpose fields such as plywood, pencil making, match splints, paper pulpwood, packing cases, toys, wooden shoes, flooring, carving, and crates. The fast decomposition rate of *A. cadamba* is also made it more compatible with the emerging agroforestry systems in various parts of India and considered to be very useful tree in agroforestry and carbon sequestration.[21]

TAXONOMICAL CLASSIFICATION

A. cadamba (Roxb) Miq. (family: *Rubiaceae*) is a miracle tree species with considerable economic potential used as a timber wood and traditional medicine resource in South and Southeast Asia, thereby J. Li et al. (2018), reported the complete chloroplast genome of *A. cadamba* which are similar to genomes from Rubiaceae family.[22] The detailed taxonomical classification of *A. cadamba* is given in Table 1.[23]

VERNACULAR NAMES AND SYNONYMS

A. cadamba is extensively available all over India and is acknowledged by various names at various places. The details of vernacular names and synonyms are listed in Table 2.[24,25]

GEOGRAPHICAL DISTRIBUTION

A. cadamba are mostly located in deciduous forests and are generally cultivated in plains. They are mostly found in Asia, Australia, and the Pacific region. In India, they are mostly found in Kerala, Maharashtra, Tamil Nadu, Madhya Pradesh, Assam, and Andhra Pradesh. They are also cultivated in India, Pakistan, Sri Lanka, Burma, Thailand, Laos, Vietnam, Cambodia, Indo-Malesia, and many other tropical regions all over the world. Native range of *Cadamba* is Australia, China, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, Vietnam, and Maharashtra. In Maharashtra, it is widely distributed over central plains of Marathwada, dry deciduous forests of Vidarbha and Western Maharashtra, and moist deciduous forests of Konkan.[26,27]

Table 1: Taxonomical classification of *Anthocephalus cadamba*

Taxonomical Hierarchy	Examples
Kingdom	Plantae
Division	Magnoliophyta
Subkingdom	Tracheobionta
Class	Asteridae
Order	Rubiales
Family	Rubiaceae
Subfamily	Cinchonoideae
Genus	*Anthocephalus*
Species	*Cadamba*

Table 2: Vernacular names and synonyms of *Anthocephalus cadamba*

Language	Name
Vernacular names	
Marathi	Kadamba
Hindi	Kadamb
Sanskrit	Kadamba
Telugu	Kadambamu
Bengali	Kadam
Tamil	Kapam, Vellai
Malayalam	Attutek
Kannada	Kadawala
English	Wild cinchona, Cadam, Kadam
Assam	Roghu, Kadam
Indonesia	Jabon
Malaysia	Kalempayan
Cambodia	Thkoow
Synonyms	*Neolamarckia cadamba* (Roxb.) Bosser
	Anthocephalus indicus var. *glabrescens* H.L.Li
	Anthocephalus morindifolius Korth
	Nauclea cadamba Roxb.
	Naucleamegaphylla (S. Moore)
	Samama cadamba (Roxb.) Kuntze
	Sarcocephalus cadamba (Roxb.) Kurz
	Sarcocephalus cadamba (Roxb.) Kurz

BOTANICAL DESCRIPTION

A. cadamba (*Rubiaceae*) is a fast-growing large tree with a broad umbrella-shaped crown and straight cylindrical bole. It has broad spreading branches and rapidly grows within 5–6 years. The branches are characteristically arranged in tiers. The tree may reach a height of 45 m with a stem diameter of 100–160 cm, and sometimes, it has a small buttress up to 2 m high [Figure 1].[26,28,29]

The barks are grayish-brown with characteristic taste and order [Figure 2]. The inner bark consists of secondary phloem, whereas the outer bark is rhytidoma with two or three narrow, wavy zones of periderm which occurs one after the other with wide secondary phloem between the sequent periderm zones; simultaneously, the inner bark consists of secondary phloem that can be differentiated into two zones namely broader collapsed phloem and narrow noncollapsed phloem. The ray cells are narrowly oblong and thin-walled. Sieve elements are arranged in radial files in between the rays. The sieve-tube members are wide and polygonal in outline with thin-walled.[30]

The shape of *A. cadamba* leaves are broadly ovate, glossy green, opposite, simple sessile to petiolate, bitter in taste, mucronate apex, glabrous surface, pinnate venation, length varying from 7.5 to 18 cm, and breadth varying from 4.5 to 16 cm [Figure 3]. Presence of unicellular, lignified trichomes, paracytic stomata, simple starch grains, and sandy balls of calcium oxalate crystals is found in the microscopic study of leaf powder. The reported stomatal number for upper epidermis (41–47) and lower epidermis (42–45), the stomatal index for upper epidermis is 27.2% and lower epidermis is 26.9%, whereas the vein islet number and vein termination number are 11 and 21.[31]

Inflorescence are clusters with terminal globose heads without bracteoles and subsessile fragrant. Flowers are yellow to orange in colour, bisexual with 5-merous along with funnel-shaped calyx, simultaneously, corolla are gamopetalous saucer-shaped with an arrow tube, the narrow lobes imbricate in bud. Five stamens inserted on the corolla tube, filaments are short and anthers are basified. Ovary are inferior, bilocular, sometimes 4-locular present in the upper part along with a spindle-shaped stigma.[32,33]

The fruitlets are numerous, somewhat fleshy, with their upper parts containing four hollow or solid structures [Figures 4 and 5]. The fruit occurs in small, fleshy capsules packed closely together to form a fleshy yellow-orange infructescence containing approximately 8000 seeds [Figure 6]. The seeds somewhat are trigonal or irregular shaped, not winged.[26]

Figure 1: *Anthocephalus cadamba* tree

Figure 2: *Anthocephalus cadamba* bark

Figure 3: *Anthocephalus cadamba* leave

Figure 4: *Anthocephalus cadamba* flower and fruitlet

Figure 5: *Anthocephalus cadamba* pseudocarp (false-fruit) with dried corolla

Figure 6: *Anthocephalus cadamba* tiny seeds

The fresh matured roots are thick but cylindrical, whitish-gray with fissures and surface rough and scars. Taproot branched with true kinds of rootlets. The powdered roots are odorless and tasteless and consists of vessel elements such as fibers, parenchyma, and few cork cells. The fibers are abundant in the powders which are narrow and long with thick lignified secondary walls. Parenchyma cells are also found clearly. In fresh condition, the cut surface of the root is smooth, with white border and yellow middle region. The microscopic characteristics of matured root consist of wide periderm and solid vascular cylinder with cork layer along with cortex amid lenticels. The periderms are scaly flacks with shallow irregular fissured crevices containing phellem, phellogen, and phelloderms. Xylem vessels are found between the medullary rays. Secondary phloem is comparatively massive unlignified, containing sieve tubes, phloem parenchyma, and starch grains.[34]

The detailed general description and pharmacognostical parameters of *A. cadamba* are depicted in Tables 3 and 4.[30-32]

Table 3: General botanical description of *Anthocephalus cadamba*

Plant parts	Physical Characteristics
Seeds	Small and muriculate
Fruits	Fleshy, orange, globose pseudocarp and yellow
Flowers	Orange colored with globose heads
Leaves	Coriaceous, entire margin, elliptical-oblong, pulvinus base, with acute or shortly acuminate
Bark	Dark brown, adjective with longitudinal fissures peeling off in thin scales
Root	Thick but cylindrical, whitish gray with fissures and surface rough and scars. Taproot branched with true kinds of rootlets

Table 4: Pharmacognostical parameters of *Anthocephalus cadamba*

Parameter	Root (% w/w)	Leaf (% w/w)	Bark (% w/w)
Total ash values	4.26	8.26	8.97
Acid-insoluble ash values	1.1	0.66	1.20
Water-soluble ash values	2.41	2.36	2.62
Sulfated ash values	5.73	4.12	4.51
Loss on drying	5.57	6.23	8.66
Water-soluble extractive values	10.0	4.8	3.2
Alcohol-soluble extractive values	5.03	4.8	4.0

ETHNOBOTANICAL INFORMATION

The plant is known to play an important economical, ecological, as well as medicinal role. According to various Indian Ayurveda practitioners and traditional herbal healers, several parts of *A. cadamba* are used for the treatment of a number of health hazards. Each and every plant part is used for the preparation of several medicines. There are several benefits of *A. cadamba* in Ayurvedic system such as inshishira, grahi, guru, vranaropana, vishtambhakrut, shukravardhana, raktapitta, atisara, arochaka, visha, kasa, and daha.[29]

Indian tribal used leaf paste in the treatment of dyspepsia and locally applied for mouth ulcer in children. Lodhas apply bruised leaves on boils for removing of subdermal inflammatory deposits.[35] Leaves are bitter, nutritious, and astringent and are also used for gargling in aphthae or stomatitis. Dried powdered leaves are used as anthelmintic and hot water extract of the leaves is used as astringents, as stomatitis, and for washing wounds in the throat.[36,37] The fresh juice of the leaf is consumed in a dose of 10–15 ml to treat leucorrhea and increased menstrual flow.[35]

The flowers are used as vegetable and as gurgle to remove the foul smell from mouth.[36] Kadam flowers are an important raw material in the production of "attar," which are Indian perfumes with sandalwood (*Santalum* spp.) base in which one of the essences is absorbed through hydro-distillation.[15]

The fruit is cooling and said to destroy the phlegm and impurity of blood when eaten.[15] Lodhas take ripened fruits as carminative/masticate.[36] Fruit juice is given during fever and gastric disturbance.[15] The fresh juice of the fruit is useful to increase breast milk in lactating women.[37]

Similarly, stem barks reported to possess astringent, febrifuge, and antiseptic and acts as diuretics.[38] Juice of the bark given orally against cough and fever and in inflammation of eyes.[15,39] Dried stem bark is also used as folk medicine (ethno medicines) in the treatment of various skin diseases, anemia, and uterine complaints and for the improvement of semen quality.[40,41] Lodhas apply stem bark paste on swelling of legs and juice to cure eye inflammation. In Konkan, the fresh juice of the bark is applied to the heads of infant when the fontanels sunken.[39] Mundas prescribe the bark paste duly suspended in water in reducing blood sugar in the patients with diabetes mellitus.[35] The paste prepared from the bark of stem and leaf of *A. cadamba* is useful to treat pain, redness, and itching due to insect bite.[42]

The tribes of Ganjam district of Odisha drink the root paste duly suspended in water in reducing blood sugar in the patients with diabetes mellitus.[37] The decoction of the root of *A. cadamba* is useful for the treatment of urinary tract infection and renal calculi.[43]

PHARMACOLOGICAL ACTIVITIES

Antidiabetic activity

Different doses of ethanolic fraction (250, 500, 750, and 1000 mg/kg body weight [body wt.])[44] and methanolic extract (200 and 400 mg/kg)[45] of stem bark of *A. cadamba* were reported for its antidiabetic (hypoglycemic) potential in alloxan-induced diabetic rats and rectifying the problems such as fatigue and irritation associated with this disease. The reported experimental studies helped in proving that 400–500 mg/kg extract of drug was effective in the treatment of diabetes, and it is thought to be due to the presence of flavonoids, which stimulated the insulin secretion. The alcoholic and aqueous extracts of the roots of *A. cadamba* also possessed the antidiabetic activity in dose 400 mg/kg body wt. and were tested against the normoglycemic and alloxan-induced hyperglycemic rats.[46] Similarly, the aqueous (400 mg/kg)[47] and methanolic extracts (200 and 400 mg/kg body wt.)[48] of the leaves had beneficial effects in reducing the elevated blood glucose level of hyperglycemic mice and rats with lipid-lowering activity. The hydroethanolic extract (100 and 200 mg/kg body wt.) of the flowering tops of *A. cadamba* was also reported for its potential hypoglycemic effect and antioxidant property in alloxan-induced diabetic rats.[49]

Antioxidant activity

The extract of *A. cadamba* whole plant (barks, leaves, flowers, and fruits) reportedly possessed potent antioxidant activity by inhibition of lipid peroxidation and by rapid increase in the superoxide dismutase (SOD) and catalase activity.[18,50] The antioxidant potential of the extracts isolated from *A. cadamba* which have the capacity to act as therapeutic agents in the treatment of radical-related pathological damage.[51] In another study, extracts, namely, AC-4 and alkaloid-rich fraction was isolated from leaves and barks of *A. cadamba* using two varied methodologies for isolation to evaluate both *in vitro* antioxidant and antiproliferative properties.[52] Simultaneously, both leaf and fruit extracts (methanol and n-hexane) exhibited strong 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging and Fe^{2+} chelating activities; however, superoxide anion scavenging activity of the fruit extract was much higher than leaf extract.[53] Similarly, the hydroethanolic extract of *A. cadamba* flowering tops displayed remarkable antioxidative potential in the DPPH, the hydrogen peroxide, the nitric oxide scavenging, the reducing power, the total antioxidant capacity, the lipid peroxidation inhibition (thiobarbituric acid-reactive substances production), and the RBC membrane stabilization assays. While in the DPPH assay, the IC_{50} value of the extract was 146.5 and 24.8 μg/ml for nitric oxide scavenging assay, whereas the extract at a concentration range of 0.50–2.0 mg/ml significantly protected the rat erythrocyte membrane against lysis induced by hypotonic solution.[54] Hot aqueous extract[55] and ethyl acetate fraction[56] of the leaves also exhibit significant and powerful antioxidant activity. Chandel *et al.* also reported the antioxidant potential of methanol extract from the bark of *A. cadamba*. Here, antioxidant activity was determined by *in vitro* assays, viz., DPPH radical scavenging assay, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical cation decolorization assay, and reducing power assay. The extract also evaluated for DNA protection activity in DNA protection assay using pBR322 plasmid DNA. In addition, the extract also showed good genoprotective potential comparable to gallic acid.[57] Similarly, the methanol extract of leaf–calli and internode–calli of this plant also possesses positive antioxidant activities in total phenolic content and DPPH radical scavenging activity assay. The leaf, twig, and calli extracts also showed the potential to protect the plasmid DNA (pBR322) against the attack of hydroxyl radicals generated by Fenton's reagent.[58]

Antitumor activity

Recently, various studies have been carried out on *A. cadamba* to evaluate its antitumor activity. Reported cytotoxicity tests on methanol extract (200 and 400 mg/kg) of *A. cadamba* leaf performing through Trypan blue method by inoculating it on Ehlrich ascites carcinoma (EAC)-treated mice and the extract showed direct cytotoxicity on EAC cell line in a dose-dependant manner and decrease in the tumor volume, viable cell count, tumor weight and elevated the life span of EAC tumor bearing mice.[59] Kamal *et al.* reported that the leaves of *A. cadamba* possess moderate cytotoxic (brine shrimp lethality bioassay) activity of crude methanol extract and lethal concentration 50 (LC_{50}) values of the extract was found 130.617 ± 0.82 μg/ml.[60] Two flavonols, viz., 6-hydroxycoumarin-(4→8)-(-)-epicatechin and 6-hydroxycoumarin-(4→8)-(-)-epicatechin-(4→6)-(-)-epicatechin, were isolated from of *A. cadamba* leaves, and both the compounds exhibited potent antioxidant and antigenotoxic activity and also showed cytotoxicity in COLO-205 cancer cell line with growth inhibition 50% of 435.71 g/ml. Both the compounds also showed moderate cyclooxygenase-2 inhibitory activity.[61] The cytotoxic potential of chloroform extract from *A. cadamba* leaves against different human cancer cell lines was also reported by Singh *et al.* Chloroform extract exerts potent cytotoxic effect against human lung (A-549), ovary (IGR-OV-1), prostate (PC-3), and central nervous system (CNS, SF-295) cancer cell lines IC_{50} of 8, 57, 49, and 39 μg/ml, respectively. Ethanolic extract was found to be active only against one cell line CNS (SF-295).[62] In 2016, Dolai *et al.* reported anticancer activity of methanol extract of *A. cadamba* stem bark. Investigation indicates that the extract (200 and 400 mg/kg) exhibit potential antitumor activity. The tumor-suppressing mechanism involved the induction of apoptosis and/or cell death followed due to DNA damage property of the methanol extract of *A. cadamba*.[63] Fatima *et al.* reported antiproliferative and antioxidant activities of methanol extract from *A. cadamba* bark along with estimation of total phenolic contents. Simultaneously methanol extract of the bark also shown significant antiproliferative activity (IC_{50}=319±4.98 μg/ml) against human cervical cancer cells when compared with standard cisplatin (IC_{50}=5.6±0.52 μg/ml) drug along with high antiradical activity demonstrated by the extract against DPPH and ABTS and the authors also suggested that the antiproliferative activity may be due to induction of apoptosis which is credited to the phenolic contents.[52] Simultaneously, preliminary cytotoxic (Brine shrimp lethality bioassay) effects of ethanol extract and its fractions of *A. cadamba* bark were reported by Abu *et al.*, and the LC_{50} values for pet-ether, chloroform fractions, and standard vincristine

sulfate were 17.78, 15.66, and 12.02 μg/ml, respectively, and the studies revealed that chloroform fractions of ethanol extracts of stem bark possess moderate cytotoxicity's effect.[64] Two new monoterpene, indole alkaloids (vincosamide-N-oxide and isodihydroaminocadambine), and seven known alkaloids and triterpenoids (such as vincosamide, vallesiachotamine, iso-vallesiachotamine, dihydrocadambine, cadambine, ursolic acid, and oleanolic acid) were isolated from the fruits of *A. cadamba*, and all the molecules were evaluated *in vitro* antiproliferative activity against human lung cancer cell line H1299, cytotoxic profile in mouse macrophage RAW 264.7 cell line, and induction of apoptosis in MCF-7 cells. Compounds vallesiachotamine and iso-vallesiachotamine were found to exhibit potent anticancer activity with IC_{50} values of 4.24 and 3.79 μM, respectively. Both compounds demonstrated significant fragmentation in the chromatin within the nucleus cells as a result of apoptosis. In addition, none of the compounds showed any toxic effect on normal cells.[65]

Nephrotoxicity

Ethanol extract of *A. cadamba* roots has a potential role in the abatement of cisplatin-induced nephrotoxicity. The nephroprotective potential of the extract (200 and 400 mg/kg) was evaluated in Wistar rats. Extract significantly attenuated nephrotoxicity induced by cisplatin which was confirmed by reducing levels of serum markers, urinary total protein, lipid peroxidation, and increased creatinine clearance. Extract also compensated deficits in the renal antioxidant system.[66] Simultaneously, aqueous extract of *A. cadamba* fruit possesses antidote and acts effectively against arsenic-induced nephrotoxicity. It was observed that administration of the crude extract (100 mg/kg, p.o.) reduces the toxic effect of arsenic trioxide on the kidney of mice.[67]

Diuretic and laxative activity

The various extracts of the barks of *A cadamba* were studied for its diuretic and laxative activity, and it was found that the methanol extract (300 mg/kg) of the bark of *A cadamba* significantly showed enhancement of the urinary output (diuresis) comparatively with the aqueous, chloroform, and petroleum ether extract, whereas the chloroform extract (300 mg/kg) reportedly produced significant laxative property.[68] Prathibhakumari and Prasad also reported the efficacy of aqueous fruit extract (200 and 400 mg/kg, p.o.) of *A. cadamba* on diuretic property in albino rats via oral route.[69]

Antihepatotoxic effects

In 1995, Kapil *et al.* reported the hepatoprotective activity of chlorogenic acid (CGA) isolated from *A. cadamba*. It was also found that the intraperitoneal (i.p) administration of CGA to mice at a dose of 100 mg/kg, i.p., for 8 days, exhibited a better liver protective action than silymarin, in carbon tetrachloride (CCl_4)-administered mice.[14] Similarly, the flowers of *A. cadamba* also reported for its promising hepatoprotective and antioxidant activity of due to inhibition of tissue lipid peroxidation and activation of tissue SOD and catalase.[70] Swarnkar *et al.* also reported that the ethanolic extract (200, 400, and 600 mg/kg, p.o) of *A. cadamba* leaves showed significant hepatoprotective effect against paracetamol-induced liver damage model in rats.[71] Methanol extract fraction of stem bark also reported hepatoprotective property against CCl_4-induced hepatotoxicity in rats.[72]

Hypolipidemic activity

From the experimental studies which were carried out by various research scholars, we can analyzed that the marked decrease in the lipid level in alloxan (150 mg/kg body wt.)-induced diabetic rats. Oral administration of root extract (500 mg/kg body wt.) of *A. cadamba* for 30 days in dyslipidemic animals resulted in effective decline in levels of total cholesterol, phospholipids, triglycerides, and lipid peroxides.[73] In one of the studies, the root of extract of *A. cadamba* was administered into rats which are induced initially with hyperlipidemia, which showed decreased plasma lipids and reactivated postheparin lipolytic activity in hyperlipidemic rats.[50] In another model, *A. cadamba* fruit extract exerted promising lipid-lowering effect with hepatic lipolytic activity.[74] Both bark and leaf of *Cadamba* were effective in bringing back the symptomatology explained in Ayurveda for Medoroga and the abnormal lipid profile to normalcy laid down in modern classics with special reference to hyperlipidemia, but the leaf is clinically effective in Medoroga and leaf is little more efficacious than bark and it is a drug of choice in the management of Medoroga.[75]

Analgesic, antipyretic, and anti-inflammatory activities

Extracts of the bark and leaf of *A. cadamba* possessed valuable properties such as analgesic, antipyretic, and anti-inflammatory activities.[72] The defatted aqueous extract of the leaves of *A. cadamba* reportedly showed significant analgesic and anti-inflammatory activity at varying doses (50, 100, 300, and 500 mg/kg).[38,76] Similarly, ethanolic extract of the leaf showed significant anti-inflammatory, analgesic, and antipyretic activity. The acute toxicity was also reported over Rats, was found to be higher than 2000 mg/kg.[77] The methanolic extract of the bark of *A. cadamba* was effectively evaluated for analgesic, antipyretic, and anti-inflammatory activities in one of the studies.[78,79]

Antifilarial and antimalarial activities

Mosquito-borne diseases such as malaria, dengue, chikungunya, filariasis, and Japanese encephalitis cause thousands of deaths per year in India as well as in other developing countries. Dimethyl sulfoxide extract of *Cadamba* slows the larvicidal effect on the filarial vector at low concentrations with LC_{50} at 0.61 ppm.[80] Similarly, methanolic leaf extract of *A. cadamba* also possess promising inhibiting effect on both growth and developmental activity against *Culex quinquefasciatus*.[81]

Sedative and antiepileptic effects

The sedative and antiepileptic activities of ethanolic extract of *A. cadamba* bark are also reported in various experimental animal models. The extract at dose of 100, 200, and 400 mg/kg p.o. showed significant increase in ketamine-induced sleeping time, and it also exhibited significant increase in latency to clonic convulsion, tonic extension, and time of death in pentylenetetrazole-induced seizures, isoniazid-induced seizures, and maximal electroshock-induced seizures models at all tested doses.[82]

Urolithiatic activity

The methanol fruit extract of *A. cadamba* also reported for its promising urolithiatic activity on calcium oxalate-induced nephrolithiasis in Wistar albino rats. The extract (200 and 400 mg/kg, p.o) was found to be effective to both curative and preventive treatment groups. Calcium oxalate crystals are found to be reduced by the extract administration as evident from Pizzolato staining and histopathological studies.[83]

Immunomodulatory activity

Hot aqueous extract of *A. cadamba* leaves have promising immunomodulating potential as indicated by the antibody response in immunized animals. Increase in interleukin-2 expression at gene as well as at protein level clearly suggests its application in immunosuppressed animals.[84]

Antivenom activity

It has been found that methanolic extract of the root bark of *Cadamba* can be used as an antidote against snakebite. It is used in neutralizing *Vipera russellii* and *Naja kaouthia* venom, which can induce hemorrhage, cardiotoxicity, neurotoxicity, defibrinogenation, and inflammation. The pentacyclic triterpenes (free or as glycosides) have a crucial significance in providing around 20% protection against snake venom.[85]

Gastroprotective effects

The antiulcer activity of aqueous and methanol extracts of *A cadamba* leaves and bark was investigated in both pylorus ligation and aspirin-induced ulcer models. Both the extracts at dose of 200 and 400 mg/kg, p.o., produced significant inhibition of gastric lesion induced by pylorus-ligation induced ulcer and aspirin-induced gastric ulcer. Simultaneously, the extracts also showed significant reduction in gastric volume, pH, free acidity, total acidity, ulcer index, and % ulcer inhibition.[86]

Anthelminthic activity

Aqueous and ethanolic extracts of stem–bark of this plant were screened for anthelminthic activity against earthworms, tapeworms, and roundworms using albendazole as reference drug. The ethanol extract was found potent than aqueous extract.[87] Simultaneously, various extracts of *A. cadamba* barks possess anthelmintic activity in a dose-dependent manner. Potency of the test samples was found to be inversely proportional to the time taken for paralysis/death of the worms. The activities were compared with the reference drug piperazine citrate. Among the tested extracts, the chloroform extract and pet-ether extract were found to possess potent anthelmintic activity while methanol extract showed moderate activity.[88] In one of the studies, anthelmintic activity was evaluated using the aquarium worm (*Tubifex tubifex*) and the study concluded that the leaves of *A. cadamba* have found to possess moderate and significant anthelmintic activity.[60] Similarly, aqueous and methanolic extracts of the leaves possess remarkable anthelminthic property which was performed on the adult Indian earthworm *Pheretima posthuma*.[89] The fresh bark juice also showed significant anthelminthic activity at 25, 50, and 100 mg/ml concentration.[90] Various extracts of *A. cadamba* roots was also evaluated for anthelmintic activity on adult Indian earthworms using piperazine citrate as reference standard and the results indicated that the chloroform and methanolic extracts were more potent than the petroleum ether extract.[91]

Wound-healing activity

Whole plant of *A. cadamba* (barks, leaves, flowers, and fruits) extract has potent wound-healing capacities which possess promising wound contraction and increased tensile strength. The results also reported that the extract possesses potent antioxidant activity by inhibiting lipid peroxidation and increase in the SOD and catalase activity.[18] Similarly, the ethyl acetate fraction of methanolic leaves extract of *A. cadamba* showed potent wound-healing activity in both excision and incision wound models along with potent antioxidant and free radical scavenging activity.[92]

Antimicrobial activity

Aqueous extracts of *A. cadamba* fruits reported promising antioxidant and antibacterial effect against *Escherichia coli, Pseudomonas aeruginosa, Yersinia enterocolitica, Staphylococcus aureus, Bacillus cereus*, and *Listeria innocua*.[93] Similarly, different solvent extracts of *A. cadamba* fruits were also screened for its antimicrobial activity against Gram-positive (*S. aureus* and *B. cereus*) and Gram-negative (*E. coli, Salmonella abony*, and *Shigella boydii*) bacterial cultures by agar well diffusion method as well as by minimum inhibitory concentration (MIC) and minimum bactericidal concentration; here, alcoholic extract showed significant antibacterial activity against *E. coli* and *S. aureus* with the zone of inhibition of

Table 5: Phytoconstituents isolated from *Anthocephalus cadamba*

Parts of the plant	Chemical constituents	References
Stem bark	18α-olean-12ene-3β-hydroxy 27, 28- dioic acid, quinovic acid, β-sitosterol, saponin B, padmakastein, β-sitosterolbehenate, tectochrysin, genistein, Leucocyanidin, 4'-glucoside of genkwanin, chrysophanol, emodin, emodin 8 β-D-glucosides, orientalone, physcion, β-sitosterol glucoside, amygdalin, prunasin, sakuranetin, puddumetin, flavanone, 5, 4'-dihydroxy-7-methoxy flavones, 2, 4'-dihydroxy-4-methoxy-6-glucosidoxychalcone, leucocyanidin, puddumin B, Naringenin-4'methylether-7-O-β-D-galactoside, taxifolin	[53,111,112,114,116]
Stem	Narigenin, apigenin, β-sitosterol, sakuranetin, prunetin, genkwanin	[53,112,114,116]
Leaves	Cadambine, 3α-dihydrocadambine, isodihydrocadambine, cadamine, isocadamine, 3β-dihydrocadambine, 3β-isodihydrocadambine, aminocadambine A, aminocadambine B, secologanin, 6-hydroxycoumarin-(4"→ 8)-(-)-epicatechin, 6-hydroxycoumarin-(4"→ 8)-(-)-epicatechin-(4→6")-(-)-epicatechin, Quercetin-3-rhamnoglucoside, kaempferol.	[53,61,112-116,118-120]
Bark	Phelasin A, phelasin B, 3-o-(α-L-rhamnopyranosyl)-quinovic acid-28-o-(β-D-glucopyranosyl) ester, 3-o-(β-D-glucopyranosyl)-quinovic acid-28-o-(β-D-glucopyranosyl) ester, cadambine, CFJ 83, isomalindan, cadamine, HFP 34, GZM 28, malindan, dihydrocadambine, GPX 71, GPX 73, isomalindan, isodihydrocadambine, GPX 51, GPX 53, Malindan.	[117,121,122]
Root bark	Ursolic acid, stigmasterol, prunetinoside, gluco-genkwanin	[53,112,114,116]
Flower	Linalool, geraniol, geranyl acetate, linalyl acetate, alpha-selinene, 2-nonanol, beta-phellandrene, alpha-bergamotene, p-cymene, curcumene, terpinolene, camphene, myrcene	[10]
Seed	D-xylose, D-mannose, D-glucose, naringenin-5-O-α-L-rhamnopyranoside, 4'-O-methylliquiritigenin-7-O-α-L-rhamnopyranoside, naringenin 4'-methylether-7-xyloside, β-sitosterol-3-O-D-galactopyranoside	[53,112,114,116,123]
Heartwood	Dihydrotectochrysin, dihydrowogonin, pinocembrin, chrysin, naringenin, kaempferol, aromadendrin, quercetin, taxifolin, 7-hydroxy-5, 2', 4'-trimethoxyflavone, 2'-hydroxy 2, 4, 4', 6'-tetramethoxychalcone, 2', 4'-dihydroxy-2, 4, 6'-trimethoxychalcone	[53,112,114,116]
Sapwood	7-O-(β-D-glucopyranosyl)-5-O-methylnaringenin, genistein, prunetin, n-pentacosane, triacontane, n-Octacosanol, β-sitosterol, ursolic acid, oleic acid, palmitic acid, stearic acid, afzelin, kaempferitrin, naringenin, β-sitosterol glucoside	[53,112,114,116]
Branches	Hydrocyanic acid, amygdalin	[53,112,114,116]
Whole plant	CGA	[14]

CGA: Chlorogenic acid

Table 6: Phytochemical screening of solvent extract of *Anthocephalus cadamba* leaves by gas chromatography–mass spectrometry

Name of the extract	Name of the compounds
Hexane extract	Hexadecanoic acid methyl ester, hexadecanoic acid ethyl ester, heptadecanoic acid ethyl ester, stearic acid methyl ester, octadecanoic acid ethyl ester, docosanoic acid methyl ester, 1,2-benzenedicarboxylic acid diisooctyl ester, tricosanoic acid methyl ester, pentacosanoic acid methyl ester, tetratetracontane
Petroleum ether extract	1,2-Benzenedicarboxylic acid, diisooctyl ester, heneicosane, tetratetracontane
Chloroform extract	Hexadecanoic acid methyl ester, octadecenoic acid methyl ester, stearic acid methyl ester, eicosane, 1,2-benzenedicarboxylic acid diisooctyl ester, tetratetracontane
Ethyl acetate extract	Benzaldehyde, benzyl alcohol, pentanoic acid 4-oxo-phenylmethyl ester, benzyl ether, tetradecanoic acid, n-hexadecanoic acid, octadecanoic acid ethyl ester, 1,2-benzenedicarboxylic acid diisooctyl ester, progesterone, tetratetracontane
Methanol extract	Dodecanoic acid, myristic acid, 2-cyclohexen-1-one-4-hydroxy-3,5,5-trimethyl-4-(3-oxo-1-butenyl), pentadecanoic acid, n-hexadecanoic acid, hexadecanamide, octadecanamide, heneicosane, 1,2-benzenedicarboxylic acid diisooctyl ester, tetratetracontane

22–24 cm and low MIC value up to 1.00 mg/ml.[94] Mishra and Siddique reported that methanolic extracts of unripened fruits possess very low MIC value and inhibited the growth of *P. aeruginosa* and *S. aureus* with MIC as low as 1.00 mg/ml.[95] Silver nanoparticles synthesized using leaf and fruit extracts were also screened for antibacterial activity by using four human pathogens, namely *E. coli, P. aeruginosa, S. aureus*, and *Bacillus subtilis*, but silver nanoparticles synthesized using leaf extract have shown predominant antibacterial activity rather than fruit extract.[96] The experimental evidence also proved that the various extracts of the leaves of *A. cadamba* has been studied by agar cup plate diffusion method, but chloroform and acetone extracts exhibited strong activity against bacteria (*E. coli, P. aeruginosa, S. aureus*, and *Salmonella typhi*) and fungi (*Aspergillus niger* and *Candida albicans*).[97] The crude methanolic extract of the leaves showed moderate broad spectrum antibacterial activity against both Gram-positive and Gram-negative bacteria. The zone of inhibitions was observed in the range of 6.5-14.5 mm for concentrations 300 µg/µl; in addition, the methanol extract of *A. cadamba* leaf showed effective antioxidative potential against DPPH and ABTS radicals with relatively moderate *in vitro* α-amylase inhibitory activities.[98] The antimicrobial analysis using the agar well diffusion method and MIC value is been used by many researchers, but the n-hexane, ethyl acetate, and ethanolic extracts of the leaf suggested that the plant extracts were bacteriostatic at lower concentration but bactericidal at higher concentration.[99] Simultaneously, *in vitro* antimicrobial assay in both methanolic and aqueous extract of *A. cadamba* bark depicted inhibitory zone for bacterial growth, but the results were found only to be significant against test bacteria *B. subtilis* and *Klebsiella pneumonia*. *Butea monosperma* revealed no methanolic as well aqueous extract activity against any test bacteria except *Proteus vulgaris* in aqua media.[100] Petroleum ether (60°C–80°C), chloroform, methanolic, and aqueous extracts of the roots were also evaluated separately for antimicrobial study; all the extracts were tested against certain Gram-positive and Gram-negative organisms by well diffusion method, but it was reported that both methanolic and aqueous extracts at the concentration of 20 mg/ml possess significant antimicrobial activity against all the tested organisms, viz., *E. coli*, *S. aureus*, *K. pneumoniae* and *P. aeruginosa*.[91]

Toxicological studies

Toxicity is the fundamental science of poisons and the ancient humans categorized some plants as harmful and some as safe; therefore, considerable attention has been directed toward identification of plants with no toxicity that may be used for human consumption.[101] The methanolic extract of *A. cadamba* barks was reported for its toxicity in various animal models. The results suggested that acute toxicity was found in animal models at doses range higher than 3000 mg/kg, and there was no mortality found. The subacute toxicity was also carried out at dose 600 mg/kg, p.o. and it suggested that at tested dose level, the extract was nontoxic and does not affect circulating red cells, hematopoiesis, or leucopoiesis. The results of the histopathology study revealed no sign and symptoms of degeneration on the isolated organs.[102] Similarly, the reported acute toxicity studies of various extracts of roots,[46] leaves,[47] and fruits[83] of *A. cadamba* was observed that all animals groups could tolerate a maximum dose of higher than 2000 mg/kg, p.o., without noticeable behavioral changes and there was no mortality found.

Geranyl acetate esterase inhibitory activity

Gupta and Ganjewala report the unique property of the methanol extract of *A. cadamba* fruit, which inhibited the geranyl acetate esterase (GAE) of lemongrass and this is the first report on GAE inhibitory activity. It was also suggested that the flavonoids present in the fruit extract act as suicide substrates ahead of cholesterol esters and GAE.[103]

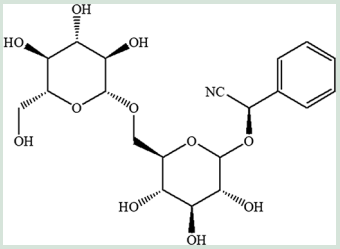
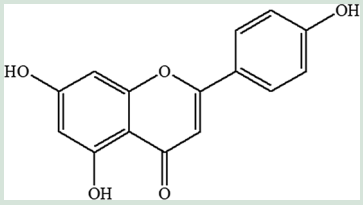
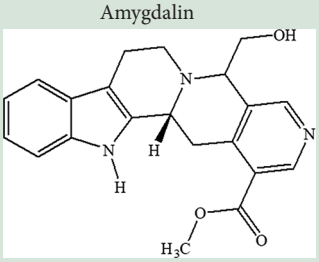
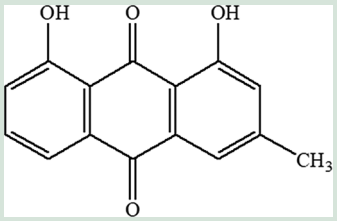
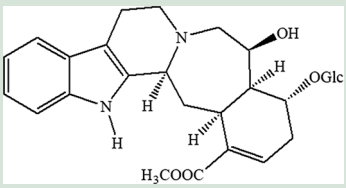
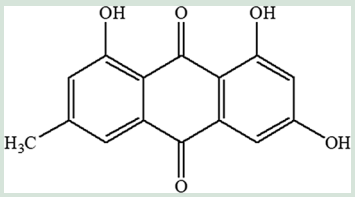
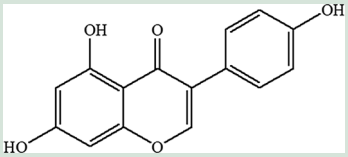
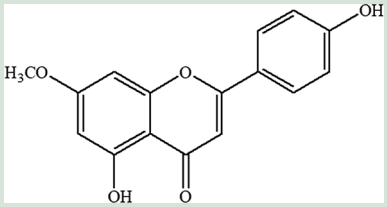
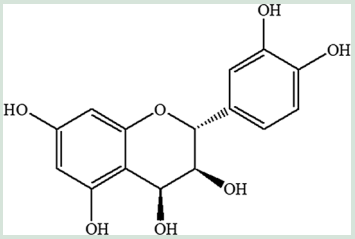
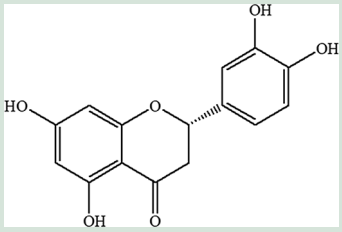
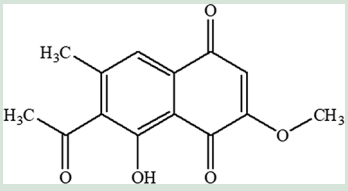
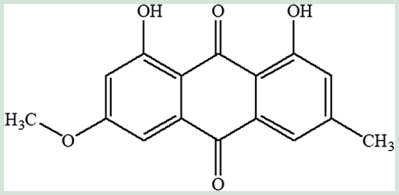
Nanotechnology

Nanoparticle formulation of a chlorophyll-rich biomolecular extract of *A. cadamba* combined with a near-infrared dye has been found to selectively kill skin cancer cells. The plant extract is particularly toxic to cancer cells as there is enhanced generation of reactive oxygen species while the dye aids in the destruction of cancer cells through photothermal therapy.[104]

Agroforestry

As *A. cadamba* is a fast-growing tropical hardwood tree and extensively used for various purposes such as plywood and pulp production and light furniture fabrication and as a raw material for the preparation of indigenous medicines. Hence, lack of genomic information is available which hampers to progress in the molecular breeding and genetic improvement of this species thereby, transcriptome profiling of differentiating stems was performed to understand *A. cadamba* xylogenesis and identified several genes responsible for xylogenesis using Illumina paired-end sequencing technology.[105] As *A. cadamba* has economically benefited, so various researchers involve to develop *in vitro* propagation and conversation of this species through apical bud and nodal and tissue culture techniques for sustainable supply of planting materials for commercial plantation.[106,107] As *A. cadamba* are economically and medicinally important plant thereby to enhance the production of bioactive compounds through in vitro plant tissue culture system are using, thereby this biotechnological approach helps in production of secondary metabolites through plant tissue culture technique and provides an alternative mean for commercial production of alkaloid[108] and flavonoids.[109] This can also help to prevent the plant from becoming endangered due to routine use of conventional methods of collection of plant material and extracting bioactive compounds. In addition, it provides great promise for controlled production of myriad of useful bioactive compounds on demand at a continuous and large scale. Similarly, 3β-isodihydrocadambine was isolated from the bark and leaf of *A. cadamba*, which is eco-friendly because for its corrosion inhibitors for mild steel.[110]

Table 7: Chemical constituents form *Anthocephalus cadamba*

Stem and bark	
 Amygdalin	 Apigenin
 Cadamine	 Chrysophanol
 Dihydrocadambine	 Emodin
 Genistein	 Genkwanin
 Leucocyanidin	 Naringenin
 Orientalone	 Physcion

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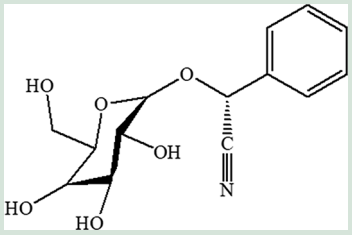
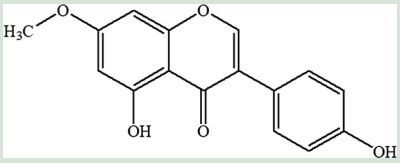
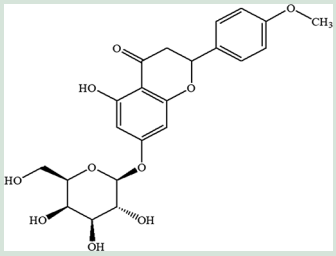
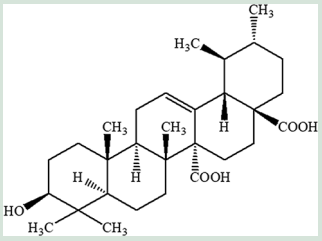
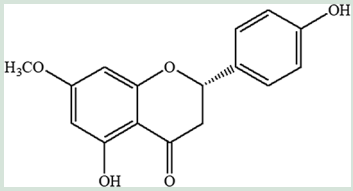
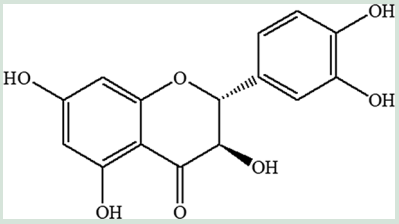
 Prunasin	 Prunetin
 Puddumin B	 Quinovic acid
 Sakuranetin	 Taxifolin
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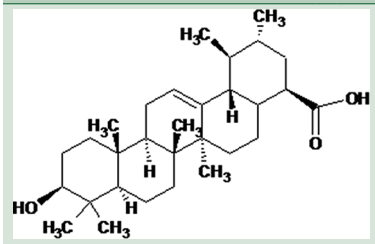
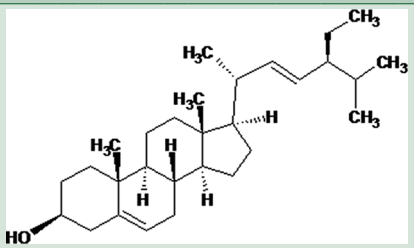
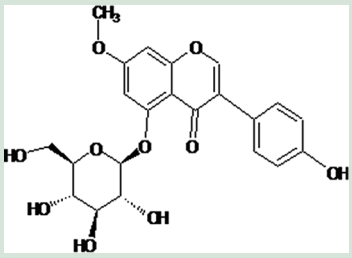
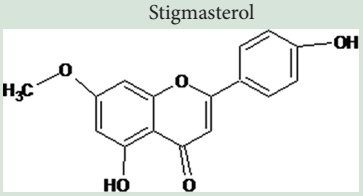
 Ursolic acid	 Stigmasterol
 Prunetinoside	 Genkwanin
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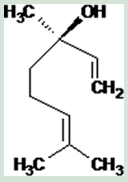
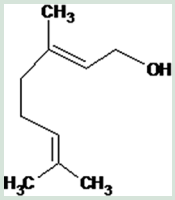
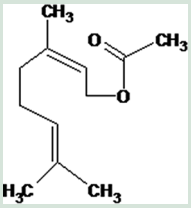
 Linalool	 Genkwanin
 Geranyl Acetate	

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Table 7: Contd...

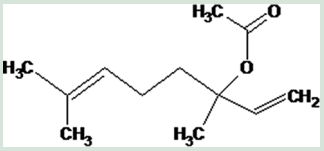
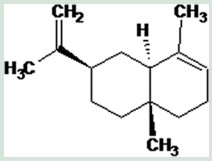
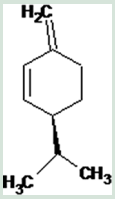
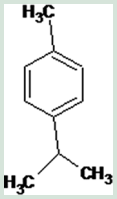
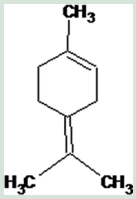
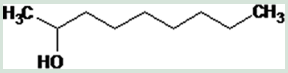
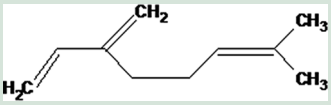
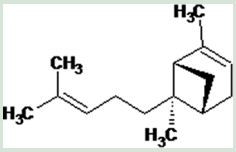
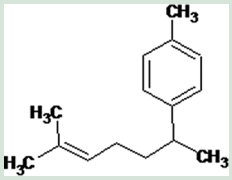
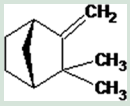
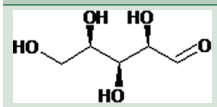
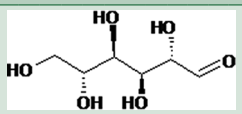
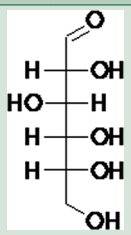
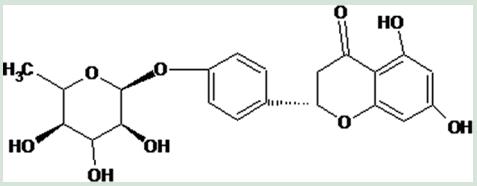
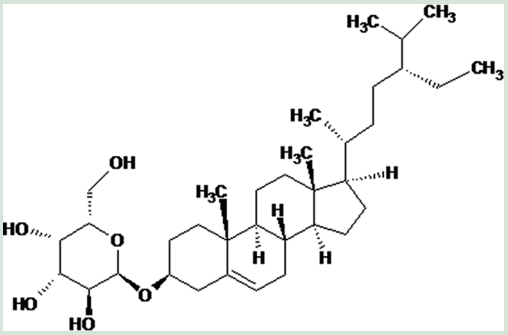
Flower	
 Linalyl Acetate	 Alpha-selinene
 Beta-phellandrene	 p-cymene
 Terpinolene	 2-nonanol
 Myrcene	 Trans Alpha-bergamotene
 Alpha Curcumene	 Camphene
Seed	
 D-xylose	 D-mannose
 D-glucose	 Naringenin-5-O-α-L-rhamnopyranoside
 β-sitosterol-3-O-D-galactopyranoside	

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Table 7: Contd...

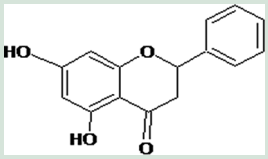
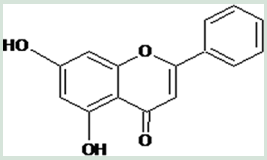
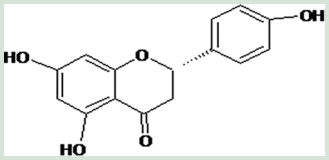
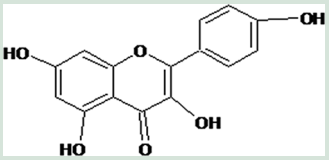
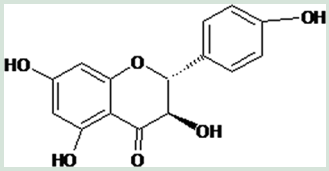
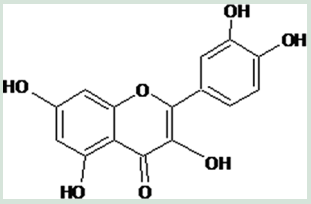
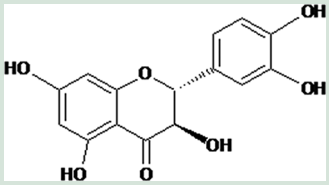
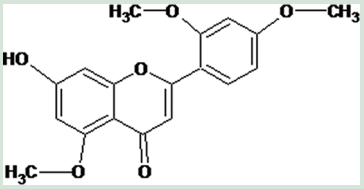
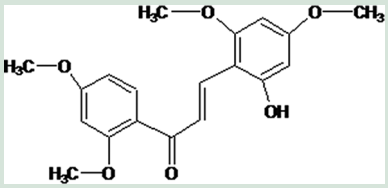
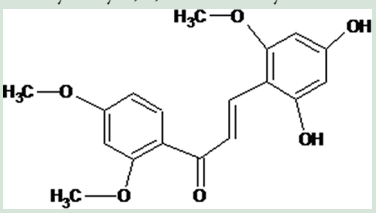
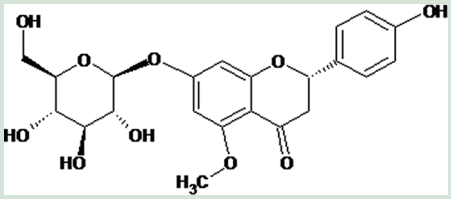
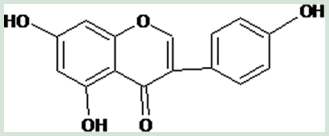
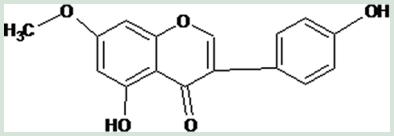
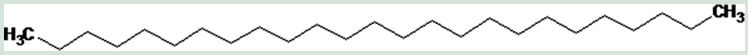
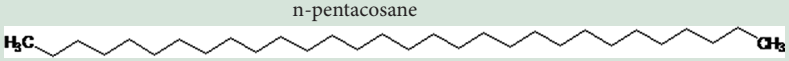
Heartwood	
 Pinocembrin	 Chrysin
 Naringenin	 Kaempferol
 Aromadendrin	 Quercetin
 Taxifolin	 7-hydroxy-5, 2', 4'-trimethoxyflavone
 2'-hydroxy 2, 4, 4', 6'-tetramethoxychalcone	 2', 4'-dihydroxy-2, 4, 6'-trimethoxychalcone
Sapwood	
 7-O-(β-D-glucopyranosyl)-5-O-methylnaringenin	
Sapwood	
 Genistein	 Prunetin
 n-pentacosane	
 Triacontane	

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Table 7: Contd...

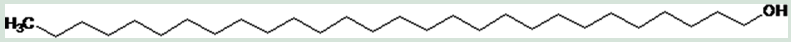
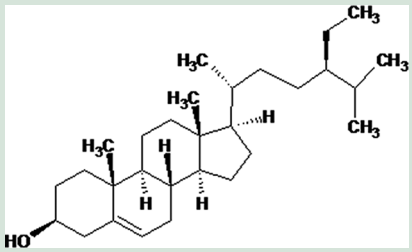
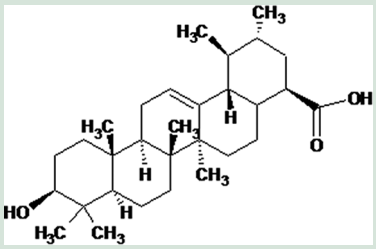
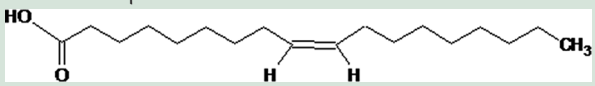
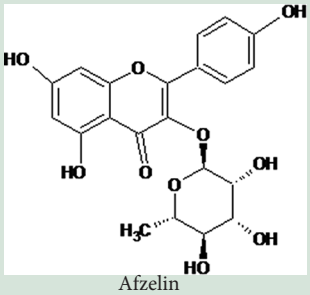
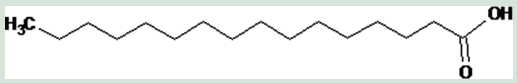
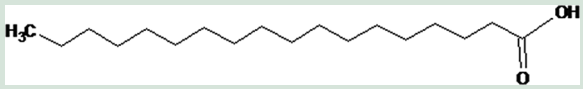
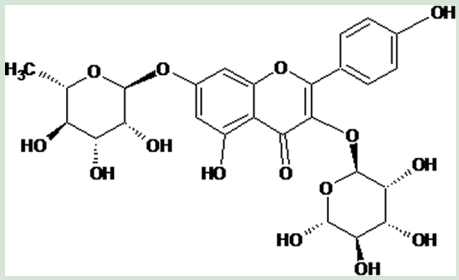
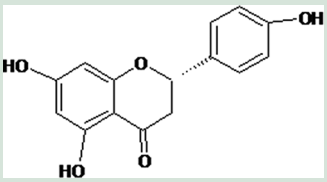
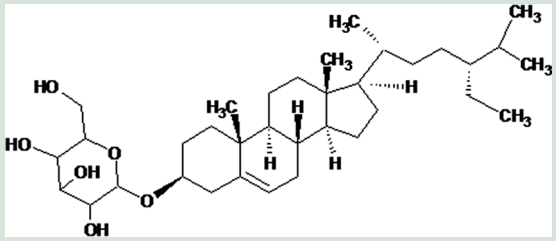
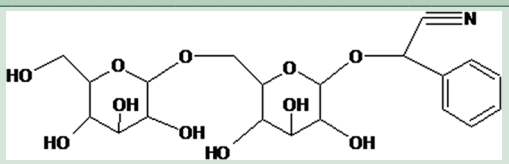
Sapwood
 n-Octacosanol
 β-sitosterol
 Ursolic acid
 Oleic acid
 Afzelin
 Palmitic acid
 Stearic acid
 Kaempferitrin
 Naringenin
Sapwood
 β-sitosterol glucoside
Branches
 Hydrocyanic acid
 Amygdalin

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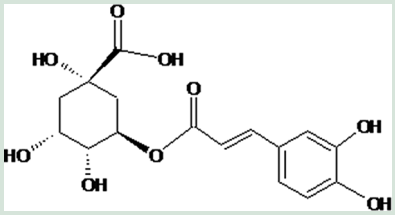
Table 7: Contd...

Whole Plant

CGA: Chlorogenic acid

PHYTOCHEMISTRY

Numerous numbers of phytoconstituents has been reported from various parts of *Anthocephalus cadamba* and as a consequence, varied classes of compound, viz., alkaloids, coumarins, terpenoids, diterpenoids, triterpenes glycosides, sterols, flavonoids, amides, fatty acids, and its esters have been isolated from its different parts through various chromatography and spectrophotometric methods.[124] The details of chemical constituents and their structures obtained from *A. cadamba* depicted in Tables 5-7.

CONCLUSION

Several parts of *A. cadamba* including stem bark, stem, leaves, bark, root bark, flower, seed, heartwood, sapwood, and branches contain a number of phytoconstituents that belong to alkaloids, coumarins, terpenoids, diterpenoids, triterpenes glycosides, sterols, flavonoids, amides, and fatty acids. These have been reported to possess various pharmacological activities such as antidiabetic, antioxidant, antitumor, nephrotoxicity, diuretic and laxative, antihepatotoxic, hypolipidemic, analgesic, antipyretic, anti-inflammatory, antifilarial antimalarial, sedative, antiepileptic, urolithiatic, immunomodulatory, antivenom, gastroprotective, anthelminthic, wound healing, antimicrobial, GAE inhibition, toxicological studies, nanotechnology, and agroforestry. Various solvent extract and their gas chromatography–mass spectrometry studies established a number of chemical compounds and their structures. This review mainly highlights about pharmacological and phytochemical studies which have illustrated therapeutic potential and phytochemical constituents of *A. cadamba*.

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Conflicts of interest

There are no conflicts of interest.

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